Morphometric Study on Papillary Muscles of Human Tricuspid Valve-Dissection Method

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Research Article

Abstract: **Background:** Aim of the present study was to observe the morphology, measurements and types of papillary muscles present in the tricuspid valve of human heart. Morphology, measurements and attachments of papillary muscles in tricuspid valve gains utmost importance in cardiac surgeries and variations in the papillary muscle morphology is a one of causes for myocardial infarction in recent times because advent in modern technologies in treatment of tricuspid valve diseases. **Materials and Methods:** This study was carried out on 96 normal fresh formalin fixed human post-mortem heart specimens. Hearts are not grouped into any criteria of sex and age. Dissection was performed according to standard techniques. Types of papillary muscles were observed and length, width and thickness of each muscle are measured and documented. **Results:** In the present study, number of papillary muscles was present with a frequency of 2-10. Maximum numbers of papillary muscles were 10 seen only in one heart (1%) and minimum numbers of papillary muscles were 2 seen in 3 hearts (3.1%). Anterior papillary muscles were present in all 96 (100%) hearts. Maximum numbers of muscles observed were 3 seen in 6 hearts (6.3%) and minimum number muscle was 1 seen in 66 (68.8%) hearts, which was normal. Two papillary muscles were seen in remaining 24 hearts (25%). Posterior papillary muscles were present in 95 (98.95%) hearts. Seven papillary muscles were observed in only 1 (1%) heart and only 1 papillary muscle was seen in 27 (28.1%) hearts. Septal papillary muscles were present in 73 hearts (76.1%). Maximum numbers of papillary muscles were 2 seen in 6 (6.3%) hearts and minimum number of muscles was only 1 seen in 67 (69.8%) hearts. In 29 hearts (30.2%) four papillary muscles were observed with a combination of 1 anterior, 2 posterior and 1 septal papillary muscle. Measurements of papillary muscles are measured and documented. **Conclusion:** This study will serve to understand the tricuspid valve complex and morphometry of different papillary muscles and it will help in various surgical procedures and cardiac treatment done on tricuspid valve.

Keywords: Tricuspid valve, papillary muscle, morphometry

Introduction

The opening of a new field of surgical endeavour often arouses interest in the detailed study of anatomy of involved part of the body. As a result of such studies, current notions may be changed and extended so as to understand better. The impetus given to tricuspid valve surgery in the course of the last few years has prompted revision of our knowledge concerning the anatomy of the normal. In the present study morphometry of papillary muscles in tricuspid valve were studied and then compared with the works of many eminent scientists in this field.

The atrioventricular valvular complex in both right and left ventricles consists of the orifice and its annulus, the cusps, the supporting chordae tendinae of various types and the papillary muscles. Tricuspid valve is made up of six major components:

1. Right atrial wall
2. Annulus
3. Three leaflets
4. Chordae tendinae
5. Papillary muscles
6. Right ventricular free wall.

Harmonious interplay of all these, together with the atrial and ventricular myocardial masses depends on the conducting tissues and the mechanical cohesion provided by the fibro elastic cardiac skeleton. All parts change substantially in position, shape, angulation and dimensions during a single cardiac cycle. The papillary muscles were small muscle groups which were present in ventricular wall and attached to cusps of valve by chordae tendinae. They contract to prevent invert or prolapse of valve. There are 2 major and 1 minor papillary muscle in the right ventricle. The major papillary muscles are located in the anterior and posterior positions. The minor papillary muscles have a medial position along with several smaller and variable muscles attached to the ventricular septum. Anterior papillary muscle: It is the largest muscle arising from the right anterolateral ventricular wall below the antero-inferior commissure of the inferior leaflet and it also blends with the right end of the septomarginal trabeculae. Posterior papillary muscle: The posterior or inferior muscle arises from the myocardium below the inferoseptal commissure. It is frequently bifid or trifid. It is irregular in size and position. Septal or medial papillary muscle: Is small, but typical and arises from the posterior septal limb of the

septomarginal trabeculae. It is often formed of several muscles of which one may be longer and more constant. All the papillary muscles supply the chordae to adjacent components of the leaflets they support. The septomarginal trabeculae (moderator band) is more or less isolated trabeculae of the bridge type, which extends from the interventricular septum to the base of the anterior papillary muscle in the lower part of the ventricle. It contains conducting myofibers from the right limb of the atrioventricular bundle.[1]

Materials and Methods

The study was carried out on 96 formalin fixed human hearts from patients who had died of non-vascular causes and were autopsied. No gross abnormalities of the tricuspid valves were noted. Study was done without any grouping of specimens on the basis of sex and age. Dissection was performed according to standard autopsy techniques. The Tricuspid valve was opened by a scalpel knife cut passing from the right atrium to the apex of the right ventricle through the lateral or acute margin of the ventricle. The interior of the heart was washed and all the blood clots were removed. The second cut was made along the anterior surface of the heart just left to the intra-ventricular groove from apex of the ventricle to annulus; care was taken not to damage the papillary muscles. Each muscle were measured by using Vernier callipers and documented. The data were summarised using descriptive statistics like frequency (number of papillary muscles), mean, standard deviation, range and 95% confidence interval (measurement of papillary muscles). All the statistical calculations were performed using software SPSS for windows {Statistical Package for Social Service (SPSS) Inc, 2004, New York} version 13.0.

Observations and Results

In the present study, number of papillary muscles was present with a frequency of 2-10. Maximum numbers of papillary muscles were 10 seen in only one heart (1%) and minimum numbers of papillary muscles were 2 seen in 3 hearts (3.1%). Anterior papillary muscles were present in all 96 (100%) hearts. Maximum numbers of muscles observed were 3 seen in 6 hearts (6.3%) and minimum number muscle was 1 seen in 66 (68.8%) hearts, which was normal. Two papillary muscles were seen in remaining 24 hearts (25%). Posterior papillary muscles were present in 95 (98.95%) hearts. Seven papillary muscles were observed in only 1 (1%) heart and only 1 papillary muscle was seen in 27 (28.1%) hearts. Septal papillary muscles were present in 73 hearts (76.1%). Maximum numbers of papillary muscles were 2 seen in 6 (6.3%) hearts and minimum number of muscles was only 1 seen in 67 (69.8%) hearts. In 29 hearts (30.2%) four papillary muscles were observed with a combination of 1 anterior, 2 posterior and 1 septal papillary muscle. In measurements of papillary muscles, anterior papillary muscle mean height was 1.49±0.44 cm; mean width was 0.82±0.21 cm and mean thickness was 0.64±0.15 cm respectively. In septal papillary muscle mean height was 0.7±0.22 cm, mean width was 0.48±0.16 cm and mean thickness was 0.34±0.12 cm respectively and posterior papillary muscle mean height was 1.05±0.37 cm, mean width was 0.63±0.17 cm and mean thickness was 0.5±0.11 cm respectively.

Discussion

The number, length and shape of papillary muscles and chordae tendinae in the right ventricle are variable. This can be of clinical significance, since the papillary muscles play an important role in right ventricle contraction by drawing the Tricuspid annulus towards the apex, thereby causing shortening of the long axis and the chamber becoming spherical for ejecting blood.[64]

Table 1: Comparison of incidence of papillary muscles

Sl. No.	Studies	No. cases studied	Percentage of papillary muscles		
			APM	PPM	SPM
1	**Present study**	**96**	**100%**	**100%**	**95.8%**
2	Balachandra N[3] *et al.*	96	100%	100%	100%
3	Gerola LR[4] *et al.*	50	100%	84%	100%
4	Nigri GR[5] *et al.*	50	100%	100%	78.5%
5	Motabagani MAB[6]	10	100%	100%	100%
6	Begum[7] *et al.*	50	92%	60%	76%
7	Wafae N[8] *et al.*	50	100%	100%	100%

Observation regarding the percentage of papillary muscles in the present study was in agreement with the work of Nigiri GR *et al*. Other works by Balachandra N *et al*., Wafae N *et al*. and Motabagani MAB are also in agreement with the present study but, percentage of septal papillary muscles noted in present study was 95.8% which was different in above mentioned studies. Possible reason for such difference is the number of specimens studied. Significant difference was observed between the present study and the study done by Begum *et al*. possible reason for such difference is the number of specimens studied. There was minimal difference noted in the present study and work done by Gerola LR *et al*., regarding incidence of percentage of both posterior

papillary muscles and septal muscles. Possible reason for such difference is the number of specimens, geography and race of specimens studied. In the present study all the papillary muscles were measured for height, width and thickness. Mean height of APM was 1.49 cm ranged between 0.6 cm to 2.9 cm, mean width was 0.8 cm ranged between 0.3 cm to 1.4 cm and mean thickness was 0.64 cm ranged between 0.2 cm and 1 cm. Mean height of PPM was 1.05 cm ranged between 0.3 cm to 3.3 cm, mean width was 0.6 cm ranged between 0.2 cm to 1.2 cm and mean thickness was 0.5 cm ranged between 0.2 cm and 0.8 cm. Mean height of SPM was 0.7 cm ranged between 0.3 cm to 1.3 cm, mean width was 0.5 cm ranged between 0.2 cm to 0.8 cm and mean thickness was 0.3 cm ranged between 0.2 cm and 0.7 cm. So, anterior papillary muscle is the largest muscle followed by posterior and septal muscles. Comparison of this observation with other studies is as follows.

Table 2: Comparison of measurements of papillary muscles

Sl. No.	Studies	No. cases studied	Measurements of papillary muscles (cm)								
			Mean height			Mean width			Mean thickness		
			APM	PPM	SPM	APM	PPM	SPM	APM	PPM	SPM
1	**Present study**	**96**	1.49±0.4	1.05±0.4	0.7±0.2	0.8±0.2	0.6±0.2	0.5±0.2	0.6±0.2	0.5±0.1	0.3±0.2
2	Gerola LR[4] *et al.*	50	0.9±0.2	0.9±0.2	1.1±0.3	1.2±0.3	0.7±0.2	1.2±0.3	-	-	-
3	Nigri GR [5] *et al.*	79	1.9	1.1	0.6	-	-	-	-	-	-

Observations of mean height was significantly higher in anterior and posterior papillary muscles and minimally lower significant in septal papillary muscles, same way observations of mean width was significantly lower in anterior and septal papillary muscles compared to study done by Gerola LR *et al*. Possible reason for such difference is the number of specimens studied. The observations of mean height of papillary muscles were in agreement with work done by Nigri GR *et al*. But none of the above mentioned authors commented about thickness of the papillary muscles. Anatomical variations of papillary muscles would be useful in newer surgical techniques like papillotomy and commissurotomy in rheumatic lesions, leaflet resection in advanced myxomatous lesions, excision of infective vegetation, transfer and rotation of leaflet segments in traumatic conditions and in correction of papillary rupture induced Tricuspid regurgitation. Tricuspid valve in congenital anomalies like Ebstein's malformations, dysplasia, straddling is complicated because the tendinous chords and papillary muscles are often abnormally short and thick. So knowledge of a detailed morphology of papillary muscle is more and more necessary for cardiothoracic surgeries of these conditions.[9]

Conclusion

The present study is to understand the anatomy of constituent parts of tricuspid valve complex not only helped in examination of these parts in cross sectional interrogation but also enhanced appreciation of valvular anomalies. Knowledge regarding high variability of papillary muscles in the valve is helpful in corrective treatment of congenital disease like Ebstein's disease and severe functional Tricuspid regurgitation. Any variation in the attachments of muscle and their number, size and shape or their absence may cause prolapse of the leaflets. Regurgitation is a consequence of deformity, shortening and retraction of one or more leaflets of the Tricuspid valve as well as shortening and fusion of the papillary muscles.[10]

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